Oracle Database Password Security

An Appreciation
Oracle Database Password Security

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Pete Finnigan – Who Am I?

- Oracle Security specialist and researcher
- CEO and founder of PeteFinnigan.com Limited in February 2003
- Writer of the longest running Oracle security blog
- Member of the OakTable
- Speaker at various conferences
  - UKOUG, PSOUG, BlackHat, more.
- Published many times, see
  - www.petefinnigan.com for links
- Influenced industry standards
  - And governments
Agenda

• Define the problem
• The password algorithms used
• Cracking passwords
• Security of passwords
• Password design
• Profile design
• Password safes
The Problem Space – High Level

• Attacking a database needs either:
  • A direct database connection (We are focusing on this one!)
  • Exploiting an application via SQL Injection or similar

• For a direct database connection we need:
  • A direct “pipe” to the database – Open or controlled routing
  • Network details – IP/host, port, SID/Service Name
  • A username and password
  • Often: we can locate almost all of the above except the password – (tnsnames, guess usernames.....)
  • BUT; often (in real sites/systems) we can also guess or find passwords
The Problem – More Details?

• Easiest way into the database is with a password:
  • That you have been given legitimately!
  • That you find written down – externally, server, database, application
  • Via shared accounts with commonly known passwords
  • Via guessed passwords for defaults or guessable named accounts
  • By cracking – i.e. password hashes available – network, server, database, external (backups or audit trails for instance)

• Combine this with
  • Lack of audit trails
  • Excessive rights for lots of users – no Least Privilege
  • Access to password hashes to allow cracking
  • Access to attempt a login – open routing
  • Weak security settings and redundancy in settings and data

• **Passwords are often a two edged problem; weak choices; lack of controls**
The Password Algorithms in The Database

- Starting in Oracle 6 there is one core password algorithm (DES)
- Starting in 11gR1 there are 2 core algorithms (DES, SHA1)
- Starting in 12.1.0.1 there are 3 core database algorithms (DES, SHA1, HTTP Digest)
- Starting in 12.1.0.2 there are 4 core password algorithms (DES, SHA1, SHA512, HTTP Digest)
- Along the way we have also had others such as ftp via XDB
- Unless you control it all algorithms exist – more shortly on this

12.1.0.2 Example – root container – sys.user$.password and sys.user$.spare4
12.1.0.1 vs 12.1.0.2

- 12.1.0.2 includes SHA2, 12.1.0.1 does not
- 12.1.0.2 does not include password hashes for common users in the pluggable containers
  - Good for stopping hash theft
  - Bad in that accounts passwords shared across all containers
DES

- Used from Oracle 6 through Oracle 10gR2
  - Actually still enabled in 11gR1 to 12.1.0.2
- Designed by Bob Baldwin – designer of NT and VMS algorithms - https://groups.google.com/forum/#!msg/comp.databases.oracle/F0uSWBy9e_Q/7bZ_l3pVroMJ - posted to usenet in 1993
  - **Note that the details posted are not 100% correct**
- Algorithm:
  - Concatenate user|password => Unicode the string => encrypt with DES using key 0x0123456789abcdef => encrypt first block => xor next block with result => take the last IV as a new KEY and repeat
  - The password hash generated is then not reversible

Strengths / weaknesses – No real attack except brute force but key is too short now
SHA1

- Used in 11gR1 through 11.2.0.4
  - Actually still available in 12.1.0.2
- Added case sensitive passwords to the database for first time
- As a result longer key space by default
- Password only is hashed, not username and password (in DES the username is the salt)
- Salt is generated by the database on password create/change
  - Salt is passed by SQL*Net to the client
  - Salt is stored in SYS.USER$.SPARE4
  - Salt is to prevent same hash generated for same password
- Fast algorithm – not good for avoiding cracking.. 😞
- SHA1 is broken -
  https://www.schneier.com/blog/archives/2005/02/sha1_broken.html
SHA2

- Only added since 12.1.0.2 – SHA2 also added to DBMS_CRYPTO
- Hinted at in 12.1.0.1 – see comments in code in .bsq file for user$ table creation for instance
- Password hash stored as T: in SYS.USER$.SPARE4 column
- Combination of SHA2 – (SHA512) and PBKDF2 algorithms
  - PBKDF2 is done in the client
  - SHA2 is completed in the server
  - As with SHA1 the password hash and salt are stored in SYS.USER$.SPARE4
- Strengths / Weaknesses
  - Much slower to crack due to PBKDF2 part so much better than SHA1 or DES for slowing cracking
  - Documented as demo already on-line back in June; known longer
HTTP Digest

- Added in 12.1.0.1 to all database accounts
- Strange addition; SHA2 added as much stronger algorithm but HTTP Digest added just before
- MD5 is of course a predecessor to SHA and SHA1 and must faster to execute than SHA2
- Same hash always generated for same password
- Can crack the password in PL/SQL:

```sql
SQL> @httpd
ORABLOG=[B2F92092A4697D6BA568B664DB4B5C74] [B2F92092A4697D6BA568B664DB4B5C74]
PL/SQL procedure successfully completed.
```

Weakest Algorithm / All Algorithms

- What does this mean? Why is this an issue?
  - Weakest hash is the obvious target – the others are then meaningless
  - Case sensitive becomes insensitive
- How do we turn off the other algorithms
  - Sqlnet.ora - SQLNET.ALLOWED_LOGON_VERSION_SERVER=8
  - Set to 12 in 12.1.0.1 for no DES password. Set to 12a in 12.1.0.2
  - Sqlnet.ora syntax changed in different versions of Oracle
- Beware
  - We cannot disable an algorithm if used – i.e. interoperability and links
- XDB
  - It is not about stopping connections / removing protocol
  - It is about stopping H: password hashes from being generated
  - Users who use XDB need this hash IF http digest is used BUT its not needed for other accounts
  - [https://docs.oracle.com/database/121/ADXDB/appaman.htm#ADXDB6110](https://docs.oracle.com/database/121/ADXDB/appaman.htm#ADXDB6110) - can downgrade the database to basic authentication
  - If we change to basic authentication then its in one sense weaker
  - We can use custom authentication in XDB
Disable Weaker Algorithms

```sql
SQL> !cat sqlnet.ora | grep SERVER
SQLNET.ALLOWED_LOGON_VERSION_SERVER=8
SQL> connect system/oracle1@7/192.168.56.86:1521/pdborcl.localdomain
Connected.
SQL> create user pwd1 identified by pwd1;
User created.
SQL> select name,password,spare4 from sys.user$ where name='PWD1';
PWD1
0AE69BE5EA84466A
S:B6D5109AB940C395800C4C58A8C61AF6ECE9C46550F987127CC7F823E0BD;H:335D5BC1C10C4D15414121AE61117521
SQL> !cat sqlnet.ora | grep SERVER
SQLNET.ALLOWED_LOGON_VERSION_SERVER=12
SQL> connect system/oracle1@7/192.168.56.86:1521/pdborcl.localdomain
Connected.
SQL> alter user pwd1 identified by pwd1;
User altered.
SQL> select name,password,spare4 from sys.user$ where name='PWD1';
PWD1
S:AE307B8F4A06C8CFED1255338AC3D89E4DF48174551EEA10F6ACA97DBE62;H:335D5BC1C10C4D15414121AE61117521
```
Cracking Passwords

Why do we need to crack passwords
- We need to test the strength of our passwords but unless they are weak we cannot fully do this
- A password cracker will take too long to test a 12 or more character password
- If we have 15 character passwords we cannot prove this without access to government level hardware and budget
- We must assume others can crack our passwords so we must make some efforts to test our own

Cracking types and more
- Connect brute force
- Default passwords
- Dictionary attacks
- Brute force
- Permutations
- Top 500, 1,000, 10,000 passwords
- Dictionary languages – Switzerland!

A simple PL/SQL based cracker can give a good overview of current password security
Cracking More...

- C based crackers – run faster than PL/SQL so can test more passwords
  - Orabf – 0rm
  - Woraauthbf – Laszlo Toth
  - Checkpwd – Alex Kornbrust
  - Many more such as JTR
- GPU crackers
  - [http://marcellmajor.com/frame_cudadbcracker.html](http://marcellmajor.com/frame_cudadbcracker.html) from Marcell Major - 200 Million hashes a second
  - IGHASGPU - 790 million hashes a second SHA1 cracker - >52 character space would null the speed increase compared to DES
  - These can also be used on a limited character set – so SHA1 and 26 characters
- Online crackers exists for some algorithms – such as md5 and DES so can be used for single hashes
- Dennis Yurichev cracker on next slide was on-line BUT NO LONGER
Cracking – Hardware Crackers

- Hardware crackers – ASIC, FPGA, GPU (Really Software?)
  - SHA512 only 364K / sec on same hardware (massively slower)
  - Approx cost 25 * £135 + 5 * £600 = £6,375 (my guess on price) + time / dev!!
- http://yurichev.com/ops_FPGA.html - 65 - 85 Million hashes a second – just built and set live, no analysis, no serious tuning
  - Because its an FPGA it can be duplicated on other FPGA hardware
  - How far can someone go with reasonable costs
  - Denis used Stratix II 60k LE; Available: XESS Xula 24K (DIP40 pkg) or De0-Nano-Soc 40K (dual core, 900mhz Arm Cortex A9 running Linux, gig Ethernet) – (Possibly 77K LE if Arm Removed) – all for £67 (chip only £95; hmmm) - £6375/67 = 95 * 60 = 5700 * 1.4M = 7.9 Billion Hashes a second – for the same small money – would get more cards for same price – possibly 1B/hps with tuning for approx £7-800 GBP
- GPU is better value ? we are comparing Windows NT and DES
- ASIC probably would be better for speed, not cost? – would need more work but custom design should always be faster
Deo-Nano-Soc FPGA
Security of Passwords

- Passwords cannot be cracked unless you can get the password hashes
- Finding a clear text password is obviously worse
- Find all hashes in database and limit access, USER$, USER_HISTORY$, EXU..$
- Find all passwords or hashes on server and remove
- Export files and datapump can contain hashes
- Data files, redo, archive logs can reveal hashes
- ALTER SYSTEM – dump files
- Access privileges and access in another schema
  - CREATE ANY PROCEDURE
  - CREATE ANY TRIGGER
  - CREATE ANY VIEW...
- Read hashes from the SGA in some circumstances
Demo: read password hashes with CREATE ANY PROCEDURE
Password Design

• Password design must be scientific
  • We cannot simply set a length based on no other factors such as lifetime and complexity of the password
  • If we must set a length then we have to design a lifetime and complexity rules
• We also must consider users ability to bypass the rules
• We must ensure that the business does not bypass the rules for some passwords – (often schemas and DBA)
• We must understand how someone could find, steal, crack, subvert passwords and use that knowledge to design strong passwords
### Demonstrate different cracker speeds and also keyspace

**Password Cracking Calculations**

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of Hashes</th>
<th>Cumulative Hashes</th>
<th>50% Time (days)</th>
<th>Time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>26.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>936</td>
<td>962.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>33,696</td>
<td>34,658.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>1,213,056</td>
<td>1,247,714.00</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>5</td>
<td>43,670,016</td>
<td>44,917,730.00</td>
<td>0.00</td>
<td>0.47</td>
</tr>
<tr>
<td>6</td>
<td>1,572,120,576</td>
<td>1,617,038,306.00</td>
<td>0.01</td>
<td>16.84</td>
</tr>
<tr>
<td>7</td>
<td>56,396,340,736</td>
<td>58,213,379,042.00</td>
<td>0.20</td>
<td>606.39</td>
</tr>
<tr>
<td>8</td>
<td>2,037,468,266,496</td>
<td>2,095,681,645,538</td>
<td>7.37</td>
<td>21,830.02</td>
</tr>
<tr>
<td>9</td>
<td>73,348,857,593,856</td>
<td>75,444,539,239,394</td>
<td>265.30</td>
<td>785,880.62</td>
</tr>
<tr>
<td>10</td>
<td>2,640,558,873,378,820</td>
<td>2,716,003,412,618,210.00</td>
<td>9,550.63</td>
<td>28,291,702.21</td>
</tr>
<tr>
<td>11</td>
<td>95,060,119,441,637,400</td>
<td>97,776,122,854,255,600.00</td>
<td>343,822.77</td>
<td>1,018,501,279.73</td>
</tr>
<tr>
<td>12</td>
<td>3,422,164,299,898,950,000</td>
<td>3,519,940,422,753,200,000.00</td>
<td>12,377,619.72</td>
<td>36,666,046,070.35</td>
</tr>
<tr>
<td>13</td>
<td>123,197,914,796,362,000,000</td>
<td>126,717,855,219,115,000,000.00</td>
<td>445,594,309.88</td>
<td>1,319,977,658,532.45</td>
</tr>
<tr>
<td>14</td>
<td>4,435,124,932,669,030,000,000</td>
<td>4,561,842,787,888,150,000,000.00</td>
<td>16,041,395,155.78</td>
<td>47,519,195,707,168.20</td>
</tr>
<tr>
<td>15</td>
<td>159,664,497,576,085,000,000,000,000</td>
<td>164,226,340,363,973,000,000,000.00</td>
<td>577,490,225,607.95</td>
<td>1,710,691,045,458,060.00</td>
</tr>
<tr>
<td>16</td>
<td>5,747,921,912,739,070,000,000,000,000</td>
<td>5,912,148,253,103,040,000,000,000.00</td>
<td>20,789,648,121,886.10</td>
<td>61,584,877,636,490.00</td>
</tr>
<tr>
<td>17</td>
<td>206,925,188,858,606,000,000,000,000,000</td>
<td>212,837,337,111,709,000,000,000,000.00</td>
<td>748,427,332,878,899.00</td>
<td>2,217,055,594,913,640.00</td>
</tr>
<tr>
<td>18</td>
<td>7,449,306,798,909,830,000,000,000,000,000</td>
<td>7,662,144,136,021,540,000,000,000,000.00</td>
<td>26,943,383,965,964,400.00</td>
<td>79,814,001,416,891,000.00</td>
</tr>
<tr>
<td>19</td>
<td>268,175,044,760,754,000,000,000,000,000,000</td>
<td>275,837,188,896,775,000,000,000,000,000.00</td>
<td>969,961,822,774,718.00</td>
<td>2,873,304,051,008,080.00</td>
</tr>
<tr>
<td>20</td>
<td>9,654,301,611,387,140,000,000,000,000,000,000,000</td>
<td>9,930,138,800,283,920,000,000,000,000,000.00</td>
<td>34,918,625,519,889,800.00</td>
<td>103,438,945,836,291,000.00</td>
</tr>
</tbody>
</table>
Crackers Can Affect Password Choice

```sql
SQL> create user aaaa identified by aaaaa;
User created.
SQL> create user zzzz identified by zzzzz;
User created.
SQL> select name,password from sys.user$ where name in ('AAAA','ZZZZ');
NAME   PASSWORD
------- --------------------
AAAA    00F5652AE69FE700
ZZZZ    7AAED8BB9D1B19F3
```

```
C:\>woraauthbf.exe -p aaaa.lis -t hash -m 5 -c alpha
...
Password found: AAAA:AAAAA:A:A
Elapsed time: 1s
Checked passwords: 874317
Password / Second: 874317
C:\>woraauthbf.exe -p zzzz.lis -t hash -m 5 -c alpha
...
Password found: ZZZZ:ZZZZZ:A:A
Elapsed time: 7s
Checked passwords: 12359760
Password / Second: 1765680
```
Designing a Suitable Password

- Password choices can be complex (or stupid!)
- A good password must
  - Be case sensitive
  - Include digits
  - Include special characters
  - Long
- How else can we make a good password?
  - Phrase based – IKnowASecurityPerson Called Pete77 – 9 long
  - A book title – gonewiththewind – 15 long
- Easy to remember?
- But don’t write down
- Passwords should be long and random
  - Password safes can generate completely random strings

Do not use on-line password generators due to the risk they are storing your passwords.
Profile Design

• Resource fields (e.g. sessions_per_user) need resource_limit to be turned on

• Fields reuse_time and reuse_max should not be used
  • In combination they do not work as you imagine
  • Better to never allow passwords to be re-used

• The field grace_time is confusing and artificially extends the life time

• The life time must be designed in combination with complexity

• Complexity function must exist to enforce the password

• Lock time must be designed based on use of the account

• Ensure global parameters – case, failed logins also match design
These are my examples, design your own..😊

### Profile Design (2)

<table>
<thead>
<tr>
<th></th>
<th>Schema</th>
<th>Built-in</th>
<th>Admin</th>
<th>Power</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed Login</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Reuse Time</td>
<td>INF</td>
<td>INF</td>
<td>INF</td>
<td>INF</td>
<td>INF</td>
</tr>
<tr>
<td>Sessions</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Lock Time</td>
<td>10 Days</td>
<td>10 Days</td>
<td>0.5 Days</td>
<td>1 Day</td>
<td>10 Days</td>
</tr>
<tr>
<td>Max Reuse</td>
<td>Never</td>
<td>Never</td>
<td>Never</td>
<td>Never</td>
<td>Never</td>
</tr>
<tr>
<td>Grace Time</td>
<td>0</td>
<td>0</td>
<td>1 Day</td>
<td>3 Days</td>
<td>0</td>
</tr>
<tr>
<td>LifeTime</td>
<td>Calc</td>
<td>Calc</td>
<td>Calc</td>
<td>Calc</td>
<td>Calc</td>
</tr>
</tbody>
</table>
Password Verify Function

```sql
CREATE OR REPLACE FUNCTION pfcl_vf
(username varchar2,
 password varchar2,
 old_password varchar2)
RETURN boolean IS
diff integer;
cnt integer;
pw_lower varchar2(256);
BEGIN

    -- convert password
    pw_lower:=NLS_LOWER(password);
    --
    IF NOT complexity_check(password, chars => 12, letter => 1) THEN
        RETURN(FALSE);
    END IF;

    -- Check if the password differs from the previous password by at least
    -- 4 characters
    IF old_password IS NOT NULL THEN
        diff := string_distance(old_password, password);
        IF diff < 4 THEN
            raise_application_error(-20012, 'Password should differ from previous ' || 'password by at least 4 characters');
        END IF;
    END IF;

    -- check dictionary words are not contained in the password
    select count(*) into cnt from pwd_names where instr(pw_lower,word)>0;
    if(cnt>0) then
        raise_application_error(-20013,'Password cannot contain a dictionary word');
    end if;

    RETURN(TRUE);
END;
/
```

- Use the 12c Core functions in utlpwmdg.sql
- Write your own simple “frame”
- Adding a verify function forces use of “replace” syntax
- Beware that use of ALTER USER IDENTIFIED BY VALUES can bypass password verification
- SQL*Plus password also can bypass rules
- Wrap and protect function
Password Safe

- There are plenty password safe software options available – commercial or free and personal or enterprise grade.
- Some examples:
  - And more - [http://www.csoonline.com/article/2877613/identity-access/top-password-managers-compared.html](http://www.csoonline.com/article/2877613/identity-access/top-password-managers-compared.html)
Password Safe – Example (1)
Password Safe – Example (2)
Password Safe – Example (3)
Don’t Bypass Protections or Create Simple Version

• Don’t use a password safe and then store connect strings
  • In text files
  • In Toad
  • OEM
  • Paper
• Do not use simple alternatives
  • Excel
  • Word
  • Text files
• Don’t use professional solution and
  • Change passwords via scripts with list output files
Conclusions

• Design strong passwords
• Ensure hashes cannot be read
• Ensure strong passwords are properly enforced
• Ensure everyone is involved – e.g. no gaps
• Use a password safe
Any Final Questions?
Oracle Database Password Security

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